receiving standard doses of epinephrine. Despite the fact that the average patient given high-dose epinephrine received 20 mg and some received more than 100 mg of epinephrine, none of these complications were detected.

Several prospective blind clinical trials of the use of high-dose epinephrine in prehospital cardiac arrest are currently under way, but results are not yet available. No definitive recommendation can be made as to which dose clinicians should use. The ACLS standards continue to recommend 7.5 to 15 μg per kg. Clinicians who use these doses are following official ACLS guidelines but may be failing to resuscitate some patients whose lives could be saved. On the other hand, using high-dose epinephrine may eventually prove to be of no long-term benefit. Indeed, it may resuscitate more patients who require intensive care unit resources for a few days before they die of neurologic complications.

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## When to Image Cervical Spine Injuries

MOST PROTOCOLS for the emergency evaluation of patients with multiple trauma call for a liberal use of cervical spine x-ray films because of the fear that failing to diagnose occult injuries could lead to catastrophic consequences. This approach has been challenged because it leads to taking a great many films for each one that identifies an injury requiring specific treatment and because asymptomatic cervical spine injury may not exist: most published cases of purported asymptomatic injury have elements that suggest that they were occult rather than truly asymptomatic. In addition, a number of studies have identified "low-risk criteria" that should essentially exclude important cervical spine injury in certain patients.

Before attempting to selectively limit cervical spine films in patients with many injuries, it is crucial to exclude patients in whom there is a clinical suspicion of cervical spine injury, for whatever reason. These include patients with underlying bone diseases that predispose them to fractures, such as diffuse ankylosing spondylitis or severe osteoporosis, and patients with high-risk mechanisms of injury, such as high-speed motorcycle accidents or dives into an empty pool. In all other patients with a potentially serious mechanism of injury, cervical spine radiography is appropriate unless all of the following criteria are met: the patient does not have neck pain, the patient does not have tenderness to direct palpation over bony spinous elements, the patient has no focal neurologic deficits, the patient is awake and normally responsive, the patient shows no evidence of intoxication with alcohol or other drugs, and the patient does not have a substantially painful injury that might alter pain perception or distract attention away from a possible cervical injury.

X-ray films of the cervical spine are critical for patients with major multiple trauma, who have signs or symptoms suggesting cervical spine injury, or other conditions that can be expected to interfere with the adequacy of clinical evaluation, such as altered mentation from head injury or intoxication, or other severely painful injuries that could distract a patient's attention. They are not helpful, however, in the evaluation of awake, alert, sober, neurologically intact persons who are asymptomatic or have only mild discomfort limited to the paraspinous muscles and soft tissues. Limiting cervical spine radiographs according to these criteria would decrease by perhaps 30% to 50% the number of films taken, with virtually no risk that clinically important injuries will be missed.

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## Terminating Paroxysmal Supraventricular Tachycardias With Adenosine

THE EFFECTS OF adenosine preparations on atrioventricular (AV) node conduction were noted as early as 1929. In the 1980s, research on adenosine accelerated, and in 1989 it was approved for the termination of acute paroxysmal supraventricular tachycardia. Adenosine is an endogenous purine nucleoside with receptors in many tissues. The mechanisms of adenosine's effects on cardiac tissue are not fully understood but appear to involve the modulation of adenylate cyclase activity and direct effects on potassium channels. Relevant clinical effects include transient depression of sinoatrial node automaticity and AV node conduction. It produces brief periods of bradycardia and will terminate most reentrant supraventricular tachycardia involving the AV node.

The efficacy of adenosine use has been studied in both the clinical setting and electrophysiology laboratories. It terminates between 90% and 95% of episodes of paroxysmal supraventricular tachycardia due to AV node reentry or AV tachycardia using an accessory pathway. Although other atrial tachycardias may not terminate, slowed conduction through the AV node may reveal an underlying atrial fibrillation or flutter rhythm. Several studies have shown that although adenosine does not terminate most ventricular tachycardias, it can be safely given to patients with hemodynamically stable, wide-complex tachycardia of uncertain origin. Termination strongly suggests an AV node reentrant mechanism. Other atrial tachycardias may be slowed enough for diagnosis of the atrial pattern, and ventricular tachycardia will usually be refractory. Occasional conversion of ventricular tachycardia that is caused by catechol-dependent mechanisms has been reported.

Adenosine is given intravenously as a rapid bolus, preferably into a large vein, followed by a fluid flush. Much of a dose may be inactivated before reaching the heart if given in a small peripheral vein. Patients who do not have response to the initial dose of 6 mg or who revert to supraventricular tachycardia shortly after conversion (approximately 30% may do so) may receive a second dose of 12 mg after one to

two minutes. A third dose of 12 mg may be given if the arrhythmia has not broken or recurs. Adenosine has been used safely in children. Recommended doses are 37.5 μg per kg repeated to a maximum of 350 μg per kg. One of the benefits of adenosine rests in its rapid metabolism within the vascular system. Following an intravenous bolus, the estimated half-life is less than 10 seconds, and total clearance occurs within 30 seconds. This translates to a rapid onset of action and a short duration for desired and undesired clinical effects.

Reported side effects include facial flushing (18%), shortness of breath (12%), chest pressure (7%), and lightheadedness or nausea (2% to 3%). Effects reported in less than 1% include palpitations, hypotension, dizziness, numbness, and occasional pressure sensations. These effects are common but usually last less than a minute. If a patient is advised of them beforehand, they are usually well tolerated. Following the intravenous bolus, the monitor may show a brief sinus pause or bradycardia with extrasystoles or short runs of tachycardia. Persistent asystole, ventricular tachycardia, or ventricular fibrillation has not been reported. There is a theoretic risk of hemodynamic collapse due to shortening of the atrial or accessory pathway refractory period followed by rapid atrial fibrillation.

Contraindications include the sick-sinus syndrome and second- or third-degree AV block, unless a functioning pacemaker is in place. Caution is advised in patients with a history of asthma or wheezing. Inhaled adenosine causes bronchospasm in patients with asthma, and experience is limited in these patients. Adenosine should not be used when a patient's clinical state requires immediate cardioversion. It has, however, been safely and successfully used in patients on concomitant β-blocker therapy and in patients with hypotension—systolic blood pressures as low as 80 mm of mercury—or congestive heart failure. Drug interactions include antagonism by methylxanthines and potentiation by dipyridamole. Dosing adjustments for patients taking these drugs are not yet available.

In summary, adenosine is a safe and effective drug for terminating supraventricular tachycardia. It compares favorably with verapamil in terms of efficiency, although it is more costly. It carries less risk of hypotension or deterioration to a more ominous rhythm. It may be used as a diagnostic tool in wide-complex tachycardia of presumed supraventricular origin and may occasionally convert triggered ventricular tachycardia. Emergency medical experience with adenosine is increasing, and trials are ongoing in the prehospital setting.

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